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THE RADIONUCLIDES OF ARSENIC PRODUCED BY DEUTERON BOMBARDMENT OF GERMANIUM.

THE RADIONUCLIDES OF ARSENIC PRODUCED BY DEUTERON BOMBARDMENT OF GERMANIUM*

by

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Note: Not a thesis, but a by-product of thesis research. Prepared for publication in Physical Review.

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An investigation was made of the radionuclides of arsenic produced by the cyclotron bombardment of a thick germanium target with 15 Mev. deuterons. After chemical separation of the arsenic[1], identification of the isotopes present was made by correlating measured values of γ, β^+, and total β half lives with maximum β energy and γ-ray energy.

Arsenic activity was measured continuously for a period of 53 days with a 4π proportional counter, a γ-γ coincidence counter, and with a thin end window Geiger Muller tube using calibrated aluminum absorbers. Gamma ray energy measurements were made using a thallium-activated sodium iodide scintillation spectrometer. The energy spectrum up to 3 Mev. was scanned continuously for the first 72 hours (Fig. 1) and an additional spectrum was obtained 52 days after bombardment.

By application of the method of least squares to 4π and coincidence counter data, the decay curves were analyzed in a total of four periods: 25.8 hours, 48.2 hours, 17.8 days and 88.9 days. Comparison of total β decay curves with those due only to positron disintegration yielded an additional period slightly greater than 70 hours. These values were verified by analysis of decay curves obtained with the end window β counter. The four experimental components shown in Fig. 2 were obtained from analysis of total β decay observed with the 4π counter.

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(1) Brownell, G. L., E. W. Backofen, E. F. White, and J. W. Irvine Jr., M. I. T. Progress Report May 1953, Contract AT(30-1)-952.

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Arsenic activity was measured continuously for a period of 58 days with a 4π proportional counter, a γ-γ coincidence counter, and with a thin end window Geiger Muller tube using calibrated aluminum absorbers. Gamma ray energy measurements were made using a thallium-activated sodium iodide scintillation spectrometer. The energy spectrum up to 3 Mev. was scanned continuously for the first 72 hours (Fig. 1) and an additional spectrum was obtained 52 days after bombardment.

By application of the method of least squares to 4π and coincidence counter data, the decay curves were analyzed in a total of four periods: 25.8 hours, 42.2 hours, 17.8 days and 35.9 days. Comparison of total β decay curves with those due only to positron disintegration yielded an additional period slightly greater than 70 hours. These values were verified by analysis of decay curves obtained with the end window β counter. The four experimental components shown in Fig. 2 were obtained from analysis of total β decay observed with the 4π counter.

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(1) Brownell, G. L., W. H. Seckofen, R. F. White, and J. W. Irvine Jr., M. I. T. Progress Report May 1953, Contract AT(30-1) 952.

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The energy of the hardest γ-ray detected with the scintillation spectrometer was 0.85 Mev. with a half life of about 29 hours. An additional γ-ray energy of 0.60 Mev. was resolved several weeks after bombardment.

Maximum β energies were found from absorption curves obtained with the end window β counter. From measurements of maximum range made at various times, the energy of the most energetic β was determined for both the 25.8 hour and the 17.8 day isotopes. In addition mass absorption coefficients were determined from semilog plots of counting rate vs. absorber thickness taken at various times. Using these values, maximum β energies were computed for the 48.2 hour and the 17.8 day isotopes. Close agreement was found for the 17.8 day isotopes by both methods.

Correlation of data indicated that the nuclidic mixture consisted of As^{71}, As^{72}, As^{73}, As^{74}, and As^{77}. Due to the absence of γ-ray energies greater than 0.85 Mev. it was concluded that As^{76} was not present in the mixture.

Since the efficiency of the 4π solid angle β counter constructed for this investigation was shown to be very nearly 100 percent for particles which escape the source, these data were used to determine absolute β activities. These activities were corrected to the time of completion of bombardment and the results specified in terms of yield for each isotope.

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Maximum β energies were found from absorption curves obtained with the end window β counter. From measurements of maximum range made at various times, the energy of the most energetic β was determined for both the 26.8 hour and the 17.8 day isotopes. In addition mass absorption coefficients were determined from semilog plots of counting rate vs. absorber thickness taken at various times. Using these values, maximum β energies were computed for the 26.2 hour and the 17.8 day isotopes. Close agreement was found for the 17.8 day isotope by both methods.

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Since the efficiency of the 4π solid angle β counter constructed for this investigation was shown to be very nearly 100 percent for particles which enclose the source, these data were used to determine absolute β activities. These activities were corrected to the time of completion of bombardment and the results specified in terms of yield for each isotope.

The following is a tabular summary of the results of this investigation:

Isotope	Method of decay	Energy (Mev)	$T_{1/2}$*	Thick target yield** (μc/μamp-hr)
As^{71}	β^+	0.66	48.2 ± 1.2 hrs.	7.6
As^{72}	β^+	3.25	25.8 ± 0.2 hrs.	64.9
	γ	0.85		
As^{73}	β^-	$0.11 > E_{max} > 0.82$	86.9 ± 9.2 days	1.1
As^{74}	β^+	0.99, 1.49	17.82 ± 0.13 days	5.2
	β^-			
As^{76}	Not present in the mixture			
As^{77}	β^-	< 0.7	> 70 hours	5 < yield < 15***

* Half lives are stated with their respective standard errors.

** The thick target yield values specified apply if the deuteron beam current was exactly 36 μamps and if the arsenic separation efficiency was 100 percent. Yield values quoted are based on β counting only and do not include orbital electron capture.

*** Based on ratios of total β to β^+ counting rates.

The Master's thesis "An Investigation of the Radionuclides of Arsenic Produced by Cyclotron Bombardment of Germanium with 15 Mev. Deuterons" submitted by these writers to the Massachusetts Institute of Technology contains details of the investigation and a complete treatment of the construction and operating technique of the $4\pi\beta$ counter. This investigation was suggested by Dr. Gordon L. Brownell of the Massachusetts General Hospital and was conducted under the supervision of Prof. Robley D. Evans.

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